# Complex Systems Group

T-13
Theoretical Division
Theory, Simulation, and Computation Directorate
Los Alamos National Laboratory

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# Contents

# Chapter 1

# Overview

The Complex Systems group is a strongly interdisciplinary group, conducting research under the umbrella of probabilistic modeling of complex systems. The group expertise includes statistical physics, nonlinear dynamics, quantum physics, as well as applied mathematics. These capabilities are applied to problems in hydrodynamics, soft matter, nanoscience, validation and verification, computational biology, and information science in support of the laboratory national security mission. The group has a mission, and strong tradition, of serving as a nucleation center for vanguard interdisciplinary research. Present and future directions include science based prediction, complex networks, epidemiological modeling, social dynamics, quantum technologies, and algorithms.

## 1.1 Mission

Our group is a unique resource to Los Alamos National Laboratory and to the nation. Our group conducts theoretical and computational research in Physics of Complex Systems. We engage in dynamic and highly interdisciplinary research, using our expertise in statistical physics, nonlinear dynamics, quantum physics, and applied mathematics.

Our group has a strong tradition of scientific leadership. We serves as a nucleation center for visionary research and interdisciplinary science in support of the laboratory national security mission. Recent and current directions include Complex Networks, Nonequilibrium Statistical Physics, Science Based Prediction for Complex Systems, and Quantum Information. The group participates in programmatic laboratory research including weapons physics research, materials modeling, stockpile stewardship, the National Ignition Facility, and more.

We have strong collaborations with nationally and internationally leading academic, industrial, and governmental research institutions. Our group has vigorous student, postdoc, and visitor programs, and a tradition of recruiting outstanding talent to Los Alamos.

With its strong interdisciplinary nature, the Complex Systems Group actively collaborates with practically all of the technical divisions at Los Alamos National Laboratory. Staff members in the group are affiliated with many centers and institutes in Los Alamos National Laboratory including the Center for Nonlinear Studies, The Quantum Institute, the Center for Homeland Security, The Lujan Center at the Los Alamos Neutron Science Center, the Center for Integrated Nanotechnology, and the Institute for Complex Adaptive Matter.

## 1.2 Research

I. **Physics of Complex Systems**

- Complex Networks
- Information Science and Algorithms
- Uncertainty Quantification and Risk Analysis
- Computational Biology and Bioinformation
- Epidemiological Modeling
- Social Dynamics and Population Dynamics

II. **Statistical and Nonlinear Physics of Soft Matter**

- Granular Matter
- Colloidal Matter
- Vortex Physics
- Macromolecules and Biomolecules
- Surface Physics

III. **Statistical Mechanics and Nonlinear Dynamics of Fluids and Plasmas**

- Statistical Hydrodynamics & Turbulence
- Fluid Instabilities
- Laser-Plasma Interactions
- Multiphase Flows
- Solid Mechanics
- Flow in Porous Media

IV. **Quantum Science**

- Quantum Computation
- Quantum Measurement
- Quantum Optics
- Quantum Field Theory
- Casimir Effect
- Nanodevices

## 1.3 Capabilities

I. **Statistical Physics**

- Renormalization Group
- Scaling Theory
- Kinetic Theory
- Critical Phenomena
- Transport Theory
- Series Expansion & Pade Approximants
- Large Deviations & instantons
- Extreme Events
- Time Series Expansions
- Fractal Analysis
- Disorder Analysis
- Random Processes

II. **Theoretical Physics**

- Field Theory
- Exactly Soluble Models
- Quantum Field Theory
- Correlated Electrons
- Quantum Physics
- Relativity
- Perturbation Theory
- Conformal Mapping

III. **Applied Mathematics**

- Continuum Theory
- Solid Mechanics
- Nonlinear waves
- Shock Waves
- Multiphase Flows
- Fluid Instabilities
- Asymptotic Analysis
- Boundary Layer Theory

IV. **Computational Physics**

— Monte Carlo

— Molecular Dynamics

— Lattice Gas and Lattice Boltzmann

— Direct Numerical Simulations

— Spectral Methods

— Shock Capturing

V. **Nonlinear Dynamics**

— Time Series Analysis

— Cycle Expansions

— Chaos

VI. **Probability Theory and Statistics**

— Monte Carlo

— Stochastic Processes

— Probability Theory

— Statistics

— Graph Theory

— Image Analysis

— Data Analysis

— Risk Analysis

— Pattern Detection

— Machine Learning

VII. **Computational Biology**

— Neural Networks

— Phylogenetic Reconstruction

— Correlation Analysis

— Agent Based Modeling

— Dimensional Reduction

## 1.4 Centers

Members of the complex systems group are currently affiliated with the following centers.

— Center for Nonlinear Science (CNLS), LANL

— Center for Integrated Nanotechnologies (CINT), LANL

— Quantum Institute (QI), LANL

— LANSCE Lujan Center, LANL

— Center for Homeland Security (CHS), LANL

— Institute for Analysis of Emerging Threats, LANL

— Department of Energy Center of Excellence in Granular Materials

— New Mexico Consortium's Institute for Advanced Studies (IAS)

— Santa Fe Institute (SFI)

— Center for HIV-AIDS Vaccine Immunology (CHAVI)

— Center of Excellence for Influenza Research and Surveillance (CEIRS), University of California, Los Angeles

— Institute for Mathematics and its Applications (IMA), University of Minnesota

## 1.5 Programs

Members of the complex systems group are currently contributing to the following laboratory programs.

— Nuclear Weapons (NW)

— Threat Reduction (TR)

— Advanced Scientific Computing (ASC)

— Quantification and Mitigation of Uncertainties (QMU)

— Validation & Verification (V&V)

— Inertial Confinement Fusion (ICF)

— National Ignition Facility (NIF)

— Department of Energy Office of Science (DOE-OS)

— Department of Energy Basic Energy Sciences (DOE-BES)

— Laboratory Directed Research and Development (LDRD)

## 1.6 Projects

### The Physics of Algorithms

Many problems in information processing important for LANL are computationally complex at a fundamental level while algorithms guaranteed to find the best solution require an exponentially large amount of time making them impractical. We will innovate a new application of statistical physics methods to develop heuristic algorithms that rapidly find good solutions. By providing a solid theoretical basis for these heuristics, statistical methods allow us to mathematically quantify the performance of these algorithms to systematically improve the design enabling high-reliability applications. Our target application will be wireless sensor networks, a technology central to the Laboratory's mission in counterproliferation and counterterrorism.

### Novel Physics Inspired Approach to Error-Correction

To overcome data corruption, redundant transmission of information is typically used. In this project, we are analyzing the performance of recently developed error-correction codes to enhance the robustness of data transmission under critical conditions. We plan to quantify performance of error-correction codes by analyzing their dependence on the signal-to-noise ratio characteristics of coding and decoding. We will develop a comprehensive theoretical framework (instanton analysis) for describing the performance of error correcting codes and this framework is used to design improved coding schemes. We are applying a novel statistical physics based approach to the classical problem of coding, and the use of this new approach holds the promise for an orders of magnitude increase in transmission efficiency.

### Energy Distributions in Granular Flows

Granular flow underlies numerous industrial processes including transportation, processing, and packing of granular products such as grains, pellets, and pills as well as natural processes such as propagation of sand dunes and volcanic flows. Recently developed experimental characterization and theoretical modeling techniques have significantly advanced our ability to model granular materials to the point that accurate measurements and quantitative predictions can be made. This project focuses on the role of energy dissipation, a defining feature of granular flows. This research quantifies how energy is distributed in granular media using analytic theoretical techniques, advanced simulation methods, and experimental characterization.

### Cooperative Phenomena in Soft Matter

Soft matter systems have remarkable and complex properties from the segregation of shaken granular matter and the jamming of colloids to the folding of proteins and the biological function of vesicles and membranes. We will use tools of statistical mechanics, kinetic theory, non-equilibrium transport, classical elasticity theory, and quantum dynamics to explore collective behavior of soft matter. Applications in physical, chemical and biological systems include granular kinetics and dense flows, geometric/topological constraints in vesicles and membranes, polyelectrolyte assemblies, soft-hard interfaces, structure-geometry function relationships in macromolecules, ultrafast spectroscopy in self-assembled structures, localization in biomolecules, single-molecule dynamics, and behavior of molecular machines.

### Nonlinear Behavior in Complex Systems

Complex systems of physical, chemical, and biological origin and man-made design and construction will be investigated using methods of nonlinear science including traditional dynamical systems, pattern formation, and localized state concepts, combined with techniques of non-equilibrium statistical mechanics, mathematical physics, and applied mathematics. Whenever possible a coordinated attack on complex systems problems will include experimental, numerical and theoretical approaches. Of particular interest are biologically-relevant localized states, novel interactions of macroscopic objects with quantum systems, design and implementation of electronic architectures using spin transport, non-equilibrium behavior of materials under high-strain-rate conditions, and general methods for science-based prediction of complex states.

### Nano-Engineered Casimir Forces

Casimir forces originate from quantum vacuum fluctuations and are the main interaction between uncharged surfaces whose separation is in the nanometer and micrometer scales. They represent both an opportunity and a challenge for nanotechnology, as they affect the fabrication and functioning of nano and microelectromechanical systems. Attractive Casimir forces could be used for contactless transmission of force between nanomachines, and repulsive Casimir forces could solve the problem of vacuum-induced sticking of movable parts in actuating nanomachines. We plan to develop theoretical and experimental tools to nanoengineer and measure Casimir forces between designed materials and structures.

### Cold Atom Quantum Liquid Mixtures

Cold atom traps, which produced dilute gas Bose-Einstein condensates (BEC's), degenerate fermion gas systems and, recently, fermion superfluidity, also offer new knobs to change the properties of the particles, such as the strength of the inter-particle interactions, continuously. The mixtures of cold atom quantum fluids also exhibit a number of quantum phase transitions: sudden changes in the nature of the ground state as the inter-particle interactions are varied. Our theoretical studies will explore the prospects for testing the description of quantum phase transitions. Our studies will also explore the prospects for creating high resolution sensors and probes as a consequence.

### Coulomb Mechanisms for Ion Damage in Insulators in the Electronic Stopping Regime

Currently, there is no understanding of the microscopic formation of damage tracks by fission fragments in the electronic stopping regime. This process is important for ceramic fuel materials needed for the President's Global Nuclear Energy Partnership. We will combine theory, simulation, and experiment to study a detailed microscopic mechanism of damage in the electronic stopping regime based on Coulomb explosion processes which result from intense electric fields generated in the ion tracks. Predictions of the theory and of large scale atomistic simulations will be tested through direct experimental investigations of track formation in LiF and UO2.

### Statistical Mechanics Approaches to Parallel Computing

The understanding and ultimately the ability to control large-scale interacting dynamical systems necessitate large-scale and exhaustive simulations of their state spaces, which cannot be solved on serial computing architectures. However, optimal parallelization of large-scale dynamical processes is highly non-trivial. In this project we develop efficient update schemes for Parallel Discrete-Event Simulations (PDES). PDES encompasses a large number of real world processes, from traffic through epidemic spread to packet flow on the internet. Virtually all agent-based models belong to the class of PDES. We will tackle two main questions: 1) the task allocation problem and 2) scalability of PDES schemes.

### Quantum Fluctuations in Bose-Einstein Condensates

High precision frequency standards such as atomic clocks are critical for applications of national significance. The most obvious example is the satellite GPS. Another emerging technology is computing using inherently quantum mechanical devices, i.e., quantum computing. Such applications require highly accurate theoretical description of macroscopic quantum states. This proposal will explore the heretofore neglected effect of quantum fluctuations on transport in states with macroscopic quantum coherence that can occur in Bose-Einstein condensates.

### Quantifying Information Flow and Information Integration in Complex Networks

Interacting systems formed by discrete elements can be represented as networks of these elements. Recognizing generic organizational principles and mechanisms that govern the global behavior of large-scale networked systems is the ultimate challenge of network research. The main function of networks is transport of some entity, which in many cases can be encoded as information. This project studies the coupling between the information flow and network structure in complex networks. The focus areas are biological (in particular protein folding networks and gene transcription networks) and social networks.

### Non-Equilibrium Stochastic Processes in Classical and Quantum Systems

Some of the most intriguing and interesting new condensed matter systems realized experimentally are those based on strongly correlated electrons confined to one or two dimensions. In this situation, electrons behave in a complicated way, dominated by collective effects, similar to those exhibited by stochastic classical systems. This relationship is rich in consequences and leads to new ways of understanding and controlling both quantum and classical aspects. The research proposed in this project will establish an effective description of such complex systems, using advanced techniques of field theory, random detrimental ensembles, and nonlinear equations, with important practical consequences.

**Avian Influenza**

The threat of pandemic human H5N1 avian influenza (AIV) has caused great concern. If this virus becomes transmissible between humans while maintaining the observed mortality rate of recent years (¿50the resulting pandemic potentially could cause hundreds of millions of deaths worldwide. At the moment, there is no vaccine or efficient treatment against this strain of influenza. Thus we urgently need to understand the potential for human infection, severe disease and transmission of these viruses. Ideally, we want to predict those characteristics (phenotype) directly from the viral strain (genotype). Genome sequencing is now standard and a vast body of genetic data is available. Unfortunately, the knowledge necessary to make the desired predictions does not exist. In this project we directly address this critical deficiency by experimentally analyzing a subset of reliable markers and combining them with new computational tools (together these establish "the functional profile") to ascertain the genotypic basis of measured differences in phenotypes among diverse (avian) influenza strains. Our objective is to develop the knowledge and tools necessary to be able to predict the pandemic potential of any novel influenza virus - this includes knowledge of gene expression in the infected cells, sequence and protein structure diversity of the viral strains, complemented with proper statistical analysis and focused mechanistic models of the viral life-cycle. The successful completion of this project will also have implications for our understanding of genotype-phenotype relations in other pathogens.

**Rational Vaccine Design: Theory and Experimental Validation**

Vaccines for human immunodeficiency virus (HIV) and Hepatitis C Virus (HCV) are not available, and influenza vaccines, while effective, depend upon the successful prediction of the epidemic strain each season. Current methods of antigen choice and vaccination schedule are not optimized to cope with the high variability of these pathogens and their interaction with the immune system. This project is a comprehensive effort to rationally design vaccines against such pathogens by applying diverse theoretical methods to the spectrum of immunological and sequence data. Our intent is to find natural or design artificial vaccine reagents that have been optimized to provide maximum coverage of circulating strains.

**Dynamics of Complex Networks: Biology, Information, and Security**

The dynamics of complex networks in biological and informational systems will be studied using a diverse set of tools including mathematical graph theory, statistical mechanics, and numerical simulation. Emphasis will be placed on understanding how the nature of the network determines the evolution of processes on the network. Significant applications will be in cell signaling networks that attempt to extend component parts into integrated systems dynamics, in protein folding network, information networks, and in complex network systems relevant to homeland security.

**Theory and Trapped Ion Quantum Simulations**

In this project, we make contributions to the theoretical efforts of the trapped ion quantum simulation experiment. Quantum simulations let us model quantum condensed matter systems that are intractable using classical computers, even with supercomputers. Our quantum simulator consists of one- and two-dimensional ordered arrays of trapped ions. Interactions between the ions are induced by laser beams. We are calculating basic atomic physics effects of these lasers, how the real interactions of the ion with each other and the trap might increase the errors in these simulations, and how to best read out the results of the simulations.

### New Mathematical Tools for the Quantum Dynamics of a Bose-Einstein Condensate

A Bose-Einstein condensate (BEC) is a new quantum state of matter that is ideally suited for studying fundamental and applied problems in quantum science and technology. Our objective in this project was to develop a new BEC quantum many-body dynamical theory based on exact, closed, linear partial differential equations (PDEs) for observable values. We have tested, for the first time, the quantum-classical correspondence in complex many-body systems, which is crucially needed to understand the condition of applicability of classical mean-field theory approaches. We have investigated new advanced quantum technologies based on BECs, such as BEC interferometers and gyroscopes.

### Secure Communications in Fiber Links Using Randomness and Nonlinearity of Optical Fibers

Optical fiber communications provide the major component of today's high-speed communications. The goal of transmitting information through optical fibers in a secure, eaves-dropping free manner is an issue of national importance. This project has investigated novel ways based on hard-ware characteristics of the fibers, in which some of the main problems and limitations of fiber optics (the inevitable irregularities and non-linearities in the fiber), can actually be exploited to camouflage and recover optical information signals that have been transported. These avenues have been made possible by the development and refinement of new technologies such as adaptive pulse shaping, the technique of dispersion management, the use of frequency filters with a broad frequency interval, the use of genetic algorithms in applying the frequency filters and the reliable use of four-wave mixing of signals.

### Quantum Devices for Electronic Circuitry and Advanced Detection

We studied coupled nano-scale electronic devices with an embedded quantum degree of freedom. Examples of the internal quantum subsystems include vibrational modes (phonons) and electronic spins. Through sufficient isolation from the extrinsic environment, it is possible to achieve a regime in which the embedded quantum subsystem is both excited and read-out by the currents in the electronic device itself. In this self-consistent regime the internal dynamics of such a hybrid device leads to novel external electrical characteristics, including strongly non-linear DC current response, generation of AC signals, negative differential conductivity, switching, and hysteretic behavior. The study of hybrid classical-quantum devices also has direct relevance to read-out schemes commonly encountered in quantum computing, as well as to ultra-sensitive detection in local probes. In quantum computing, various schemes for detection and measurement of single spin by means of a classical device, such as a Field Effect Transistor (FET), or Scanning Tunneling Microscope (STM) have been proposed. However, to determine the feasibility and effectiveness of such schemes it is necessary to self-consistently include the effects of the measurement process on the quantum subsystem (back-action). The coupled electro-mechanical configurations can also function as an ultra-sensitive detector of motion of read-out cantilevers in scanned probes (e.g., AFM and MRFM), capable of detecting motion as small as the zero point oscillations. Using squeezed states, detection beyond this fundamental limit is possible. This provides the potential for enhancing the state of the art in scanned probes, with applications that include qubit readout in quantum computing.

**Shedding Light on the Mechanical Unfolding of Individual Proteins**

We are studying the mechanical unfolding of well defined bio-polymers using a combination of single-molecule force microscopy (FM) and single-molecule fluorescence spectroscopy (SMS). Our investigation is focused on understanding the relationship between the fluorescence and folding stability of green fluorescent proteins (GFPs). FM can be used to construct thermodynamic properties, specifically free energy landscapes. SMS in turn, probes the local electrostatics, structure, and solvation. Combining these two techniques in a single experiment will provide us with information that spans multiple length scales and time scales.

**Lagrangian Measurements of Fluid Mixing**

Turbulent mixing is of deep fundamental interest and is a forefront problem of national importance. We will study the mechanisms of mixing whereby disparate materials are brought into close contact and ultimately mixed by molecular processes. The systems we are studying are Rayleigh-Taylor mixing important to inertial confinement fusion and nuclear weapons physics applications, shear induced mixing in gravity-driven overflows that are relevant to critical problems in global climate change prediction and dispersal of chem-bio-rad materials such as might occur in urban terrorism scenarios. Our combined approach of experiment, numerics and theory is designed to improve our predictive capability in these areas.

**Dynamics of Quantum Phase Transitions**

This project is a study of the dynamics of phase transitions (with the special focus on quantum phase transitions). This has both fundamental and applied significance. It offers the possibility to create large quantum superpositions (so-called "Schroedinger cats") and to process information in ways that are more efficient than in the classical setting. Understanding the dynamics of the transition into the condensate is required to make use of these possibilities. In particular, there are designs of quantum computers that undergo a phase transition in the course of their operation ("adiabatic quantum computing"). Their implementation requires careful understanding of the dynamics of the phase transition.

### Nonlinearity and Chaos in Spatially Extended Dynamical Systems

Nonlinearity and chaotic behavior is ubiquitous in real-world systems. In the case of nonlinear Hamiltonian dynamical systems (such as tracer dynamics in incompressible flows), little is known about the dynamical properties of chaotic trajectories in particular about the so-called "sticky behavior" of the trajectories at the (spatial) boundaries separating regular and chaotic regions. Application areas includes tracer advection in incompressible flows, which in case of passive tracers is a Hamiltonian chaotic dynamics, however for tracers with inertia the velocity field of tracers becomes compressible. In this project, we have characterized this transition in terms of orbit properties as the inertial parameters are turned on.

### Bose-Einstein Condensate Physics: Dynamics and Applications

Dilute gas Bose-Einstein Condensates (BEC's) created in neutral atom traps are prime candidates for realizing ultra-high resolution sensors that can detect weak, static fields and forces. The suitability of BEC-matter (meta-stable dilute gases of integer spin neutral atoms contained and cooled in atom traps to temperatures as low as nano-Kelvins) for this purpose derives from its ultra-low energy, its exquisite sensitivity to minute changes in the external potential and from the BEC's quantum coherent nature. As giant quantum waves with all particles moving in near-perfect lockstep coherence, the BEC's can exhibit interference fringes of near-perfect visibility and full contrast. By splitting and recombining the BEC and measuring the phase difference accumulated by the split BEC's, the BEC technology can create sensors that are comparable in sensitivity to the most accurate, commercial gravitometers currently available. In addition, contrary to the most sophisticated gravitometer devices, the BEC-interferometers could be portable, perhaps hand-held devices with measurement and repetition rates of a few seconds.

### Solid-State Quantum Information Processing: A New Approach to Demonstrate Quantum Entanglement

Quantum computation is a revolutionary new paradigm that has experienced tremendous growth since the mid 1990s and has inspired a number of ingenious schemes whose long-term goal is to realize a large-scale, fast, parallel, and easily fabricated quantum computer (QC). Silicon-based solid-state proposals using spins of dopants, such as P, as qubits are attractive because of the long spin relaxation times and the potential for scaling the device to a large number of qubits and integrating the QC with existing silicon technology. We propose a modified Kane architecture in which we tackle the difficult fabrication and addressing problems by simplifying the device structure and utilizing an existing, reliable optical detection readout method. The device consists of linear arrays of P atoms, which will be entangled through their exchange interactions. Scanning tunneling microscopy is used to fabricate the device and an external magnetic field and a large field gradient enable individual spin addressability. The lone P electron spin is used to control the nuclear spin qubit orientation. Excitons, generated in the substrate via a laser, are used to probe the spin states. A He-3 cryostat-based spin manipulation and readout system has been developed but many challenges exist in making a nano-scale quantum device in a real materials system.

## New Approaches to Quantum Computing and the Dynamics of Quantum Phase Transitions

We will carry out a coordinated theoretical and experimental study of quantum phase transitions in ultra-cold gaseous Bose-Einstein condensates (BECs). Quantum phase transitions occur at absolute zero temperature and can only be described by the laws of quantum mechanics, in contrast to classical phase transitions such as the freezing of liquid water to solid ice. BECs are an ideal practical system in which to study the physics of quantum phase transitions. The new knowledge from this program is necessary to implement quantum computation in BEC's. We expect that it will also lead to powerful new nonstandard approaches to quantum computing.

## Cold Atom Quantum Simulators

We are developing cold atom quantum simulators that ultimately will solve otherwise unsolvable quantum mechanical problems. This will step us closer towards building a universal quantum computer, which we are currently unable to build. We are constructing simulators based on ion trap and optical lattice technologies. A novel feature of our project is the test of our ability to control large quantum systems by benchmarking the simulators' results against numerical and analytical solutions to the same problems. In the process, we are systematically improving techniques of controlling and measuring quantum systems along a path towards a large universal quantum computer.

## Statistical Physics of Infrastructure Networks

We are developing a methodology based on statistical physics for analysis of complex network dynamics and flow. By capturing the collective dynamics, we will develop computationally efficient models for probabilistic analysis of large networks. Our analytical and numerical research will be applied to and validated against three infrastructure networks: the power grid, mobile communications, and epidemic spread. We will determine the mechanisms underlying system failures and infrastructure vulnerabilities and develop methods for optimizing network performance. This research will significantly advance fundamental understanding of man-made and natural networks and supply powerful methods for solving real-world problems within the laboratory mission.

## Statistical Properties of Granular Chains

Our project goal is to develop theoretical and computational models of filamentary objects in non-thermal driving conditions, and to translate such models into efficient computer simulations. We are using macroscopic chains as a model for microscopic macromolecules. We characterize statistical properties of chains driven away from equilibrium including their dynamics and conformations. To validate the theoretical and computational models, we will analyze data from vibrated chains experiments. Results of this research will help us better understand macromolecules and biomolecules such as DNA. It will also help us better describe and control flow and packing of granular materials such as powders.

# Chapter 2

# Legacy

## 2.1 Leadership

### Group Leaders

— Doyne Farmer, 1988-1991

— Alan Lapedes, 1991-1994

— Gary Doolen, 1994-2001

— David Sharp, 2001-2005

— Eli Ben-Naim, 2006-

### Leadership

— Frank Alexander, Group Leader, Information Sciences, LANL

— Shiyi Chen, Dean, University of Beijing, China

— Shiyi Chen, Chair, Mechanical Engineering Department, Johns Hopkins University

— Doyne Farmer, Founder, Complex Systems Group, LANL

— James Glimm, President, American Mathematical Society

— Brosl Hasslacher, Founder, Institute for Physical Sciences

— Edward MacKerrow, Founder, Institute for Analysis of Emerging Threats, LANL

— Ronnie Mainieri, President, Institute for Physical Sciences

— David Sharp, Chief Science Officer, LANL

— James Theiler, Team Leader, Remote Sensing and Space Science, LANL

— Zoltan Toroczkai, Deputy Director, Center for Nonlinear Studies, LANL

## 2.2 Awards

### APS Fellows

— Gennady Berman

— Shiyi Chen

— Gary Doolen

— Harvey Rose

— David Sharp

### LANL Fellows

— Shiyi Chen

— Donald Dubois

— Peter Milonni

— David Sharp

### AAAS Fellows

— David Sharp

### IOP Fellows

— Eli Ben-Naim

### R&D 100 Awards

— Gary Doolen & Shiyi Chen

— Brosl Hasslacher & Gary Doolen

### Raymond and Beverly Sackler Prize

— Christopher Jarzynski

### LANL Fellows Prize

— Shiyi Chen

— Bradley Plohr

— Doyne Farmer

## LANL Distinguished Performance Award

— Gary Doolen

— Matthew Hastings

— Shuling Hou

— Charles Reichhardt

— Harvey Rose

— Rolando Soma

## Defense Programs Award of Excellence

— Shiyi Chen

— David Sharp

## LANL Postdoctoral Fellows Awards

— Eli Ben-Naim, Director Fellow

— Shiyi Chen, Oppenheimer Fellow

— Michael Chertkov, Oppenheimer Fellow

— Diego Dalvit, Director Fellow

— David Egolf, Feynman Fellow

— Doyne Farmer, Oppenheimer Fellow

— Hasan Guclu, Director Fellow

— Matthew Hastings, Feynman Fellow

— Christofer Jarzynski, Director Fellow

— Seth Lloyd, Director Fellow

— Hanna Makaruk, Director Fellow

— Adilson Motter, Director Fellow

— Erzsebet Ravasz, Director Fellow

— Charles Reichhardt, Feynman Fellow

— David Roberts, Director Fellow

— Razvan Theodorescu, Director Fellow

— Zoltan Toroczkai, Director Fellow

— Nicholas Tuffilaro, Director Fellow

— Timothy Wallstrom, Director Fellow

— David Wolpert, Director Fellow

## 2.3 Postdocs

— Frank Alexander, Group Leader, Los Alamos National Laboratory

— Eli Ben-Naim, Group Leader, Los Alamos National Laboratory

— Hudong Chen, Scientist, Exa Research

— Shiyi Chen, Professor, Johns Hopkins University

— Michael Chertkov, Staff Member, Los Alamos National Laboratory

— Yeo-Jin Chung, Professor, Southern Methodist University

— Colm Peter Connaughton, Postdoc, Los Alamos National Laboratory

— Diego Dalvit, Staff Member, Los Alamos National Laboratory

— Gary Dilts, Staff Member, Los Alamos National Laboratory

— David Egolf, Professor, Georgetown University

— Robert Farber, Senior Scientist, Environmental Molecular Sciences Laboratory

— Doyne Farmer, Professor, Santa Fe Institute

— Walter Fontana, Professor, Harvard University

— Xiaoming Gao

— Eugene Gavrilov, Staff Member, Los Alamos National Laboratory

— Sandip Ghosal, Professor, Northwestern University

— Tal Grossman, deceased

— Hasan Guclu, Postdoc, Los Alamos National Laboratory

— Matthew Hastings, Staff Member, Los Alamos National Laboratory

— Xiaoyi He

— Shuling Hu, Affiliate, Los Alamos National Laboratory

— Christofer Jarzynski, Professor, University of Maryland

— Dmitry Kamenev

— Zbigniew Karkuszewski

— Chris Langton

— Hai-Qing Lin

— Seth Lloyd, Professor, Massachusetts Institute of Technology

— Eduardo Lopez, Postdoc, Los Alamos National Laboratory

— Pavel Lushnikov, Professor, University of New Mexico

— Ronnie Mainieri, President, Institute for Physical Sciences

— Hanna Makaruk, Staff Member, Los Alamos National Laboratory

— Guy Mcnamara, Staff Member, Los Alamos National Laboratory

— Adilson Motter, Professor, Northwestern University

— Dima Mozyrsky, Staff Member, Los Alamos National Laboratory

— Zoltan Neufeld, Professor, University College Dublin, Ireland

— Robert Owczarek, Staff Member, Los Alamos National Laboratory

— Paolo Patteli, Staff Member, Los Alamos National Laboratory

— Avner Peleg, Professor, Buffalo University

— Erzsebet Ravasz, Research Professor, Harvard University

— Jan Rehacek

— Charles Reichhardt, Staff Member, Los Alamos National Laboratory

— David Roberts, Postdoc, Los Alamos National Laboratory

— Nandakishore Santhi, Postdoc, Los Alamos National Laboratory

— Mikhail Stepanov, Professor, University of Arizona

— Tsutomu Shimomura, Professor, University of California, San Diego

— Felipe Siquiera de Souza Da Rosa, Postdoc, Los Alamos National Laboratory

— Rolando Soma, , Postdoc, Los Alamos National Laboratory

— James Theiler, Staff Member, Los Alamos National Laboratory

— Razvan Theodorescu, Postdoc, Los Alamos National Laboratory

— Zoltan Toroczkai, Professor, Notre Dame University

— Nicholas Tuffilaro, Scientist, Agilient Technologies

— Timothy Wallstrom, Staff Member, Los Alamos National Laboratory

— Xidi Wang, Scientist, Citibank

— David Wolpert, Senior Scientist, NASA

— Raoyang Zhang, Ssientist, Exa corporation

— Scott Zoldi, Senior Director for Analytic Science, Fair Isaac Corporation

## 2.4 Recruitment

The following T-13 postdocs were converted to staff member positions at LANL.

— Frank Alexander

— Eli Ben-Naim

— Shiyi Chen

— Michael Chertkov

— Timothy Clark

— Diego Dalvit

— Gary Dilts

— Robert Ecke

— Robert Farber

— Doyne Farmer

— Eugene Gavrilov

— Matthew Hastings

— Xiaoyi He

— Shuling Hu

— Christopher Jarzynski

— Alan Lapedes

— Ronnie Mainieri

— Hanna Makaruk

— Guy Mcnamara

— Dima Mozyrsky

— Robert Owczarek

— Paolo Patteli

— Charles Reichhardt

— Tsutomu Shimomura

— Zoltan Toroczkai

— James Theiler

— Timothy Wallstrom

## 2.5 Former Staff Members

— Shiyi Chen, Professor, Johns Hopkins University

— Timothy Clark, Research scientist, Northrup Gruman

— Gary Doolen, Affiliate, Los Alamos National Laboratory

— Donald Dubois, Affiliate, Los Alamos National Laboratory

— Robert Farber, Senior Scientist, Environmental Molecular Sciences Laboratory

— Doyne Farmer, Professor, Santa Fe Institute

— Brosl Hasslacher, deceased

— Shuling Hu, Affiliate, Los Alamos National Laboratory

— Chris Jarzynski, Professor, University of Maryland

— Edward MacKerrow, IAT-1, Director, Institute for Analysis of Emerging Threats

— Ronnie Mainieri, President, Institute for Physical Sciences

— Mark Mineev, X-1, Staff Member, Los Alamos National Laboratory

— David Sharp, Chief Science Officer, Los Alamos National Laboratory

— Zoltan Toroczkai, Professor, Notre Dame University

## 2.6 Books

— Complex networks
E. Ben-Naim, H. Frauenfelder, Z. Toroczkai, Editors,
Springer, 2004.

— Crossover-time in Quantum Boson and Spin Systems,
G. P. Berman, E. N. Bulgakov, D. D. Holm,
Springer-Verlag, 1994.

— Introduction to Quantum Computers,
G. P. Berman, G. D. Doolen, R. Mainieri, V. I. Tsifrinovich,
World Scientific, 1998.

— Quantum chaos: A harmonic oscillator in a monochromatic wave,
D. I. Kamenev, G. P. Berman,
Rinton, 2001.

— Modern Physics and Technology for Undergraduates,
L. Folan, V. I. Tsifrinovich, G.P. Berman,
World Scientific, 2003.

— Introduction for Quantum Neural Technologies,
A. A. Ezhov, G. P. Berman,
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— Perturbation Theory for Solid-State Quantum Computation with Many Quantum Bits,
G. P. Berman, D. I. Kamenev, V. I. Tsifrinovich,
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— Magnetic Resonance Force Microscopy and a Single Spin Measurement,
G. P. Berman, F. Borgonovi, V. N. Gorshkov, V. I. Tsifrinovich,
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— Predictability: Quantifying Uncertainty in Models of Comples Phenomena,
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Elsevier, 1999.

— Primer on Neural Nets,
J. Cowan, D. H. Sharp,
Denlingers, 1990.

— Lattice Gas Methods: Theory, Application, and Hardware,
G. D. Doolen, Editor,
MIT, 1991.

— Frontiers of Supercomputing II: A National Reassessment,
G. D. Doolen, Editor,
MIT, 1995.

— Lattice Gas Methods for Partial Differential Equations,
U. Frisch, B. Hasslacher, G. D. Doolen, Editors,
Perseus, 1989.

— Advances in Fluid Turbulence,
G. D. Doolen, Editor,
North Holland, 1989.

— Cellular Automata,
D. Farmer, T Toffoli, Tommaso, S. Wolfram, Editors,
North-Holland, 1984.

— Evolution, Games and Learning: Models for Adaptation in Machines and Nature,
D. Farmer, A. S. Lapedes, N. Packard, B. Wendroff, Editors,
Elsevier, 1987.

— Artificial life II,
C. Langton, C. G. Langton, C. G. Farmer, J. D. Farmer, S. Rasmussen, Editors,
Addison-Wesley, 1992.

— How Neural Nets Work,
A. S. Lapedes
Los Alamos National Laboratory, 1988.

— Lasers,
P. W. Milonni and J. H. Eberly,
Wiley, 1988.

— The Quantum Vacuum: An Introduction to Quantum Electrodynamics,
P. W. Milonni,
Academic Press, 1993.

— Chaos in Laser-Matter Interactions,
P. W. Milonni, M. L. Shih, and J. R. Ackerhalt,
World Scientific, 1987.

— Fast Light, Slow Light and Left-Handed Light,
P. W. Milonni,
Taylor & Francis, 2004.

## 2.7 Los Alamos Science

— Error Analysis and Simulations of Complex Phenomena,
M. A. Christie, J. Glimm, J. W. Grove, D. M. Higdon, D. H. Sharp, M. Wood-Schultz,
Los Alamos Science 29, 6 (2005).

— Complex Networks - The Challenge of Interaction Topology,
Zolt Toroczkai,
Los Alamos Science 29, 94 (2005).

— Intermittency and Anomalous Scaling in Turbulence,
M. Chertkov,
Los Alamos Science 29, 124 (2005).

— Field Theory and Statistical Hydrodynamics: The First Analytical Predictions of Anomalous Scaling,
M. Chertkov,
Los Alamos Science 29, 181 (2005).

— QMU and Nuclear Weapons Certification - What's Under the Hood,
D. H. Sharp, M. M. Wood-Schultz,
Los Alamos Science 28, 47 (2003).

— Understanding Why - Dissecting Radical Islamic Terrorism with Agent-Based Simulation,
E. P. Mackerrow,
Los Alamos Science 28, 184 (2003).

— Quantum Information Processing: A Hands-on Primer,
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— Factoring to Phase Estimation: A Discussion of Shor's Algorithm,
E. Knill, R. Laflamme, H. Barnum, D. Dalvit, J. Dziamaga, J. Gubernatis, L. Gurvits, L. Viola, W. Zurek,
Los Alamos Science 27, 38 (2002).

— Schrodinger Cats in Atom-Trap BECs,
D. Dalvit, J. Dziamaga,
Los Alamos Science 27, 166 (2002).

— Lattice-Boltzmann Fluid Dynamics - A Versatile Tool for Multiphase and Other Complicated Flows,
S. Chen, G. D. Doolen, K. Eggert,
Los Alamos Science 22, 98 (1994).

— Toward Improved Prediction of Reservoir Flow Performance - Simulating Oil and Water Flows at the Pore Scale,
J. Bukles, R. Hazlett, S. Chen, K. Eggert, D. Grunau, W. Soll,
Los Alamos Science 22, 112 (1994).

— Mixing and Chaotic Microstructure,
Y. Deng, J. Glimm, D. H. Sharp,
Los Alamos Science 21, 124 (1993).

— The Lost Cafe,
G. C. Rota,
Los Alamos Science 15, 23 (1987).

– Monte Carlo at Work,
G. D. Doolen, J. Hendricks,
Los Alamos Science 15, 142 (1987).

— Discrete Fluids,
B. Hasslacher,
Los Alamos Science 15, 175 (1987).

— Mathematics, Philosophy and Artificial Intelligence, A dialog with Gian-Carlo Rota and David Sharp,
Los Alamos Science 12, 92 (1985).

— Frontiers of Supercomputing,
B. Buzbee, N. Metropolis, D. H. Sharp,
Los Alamos Science 9, 64 (1983).

— Order in Chaos: Review of the CNLS Conference on Chaos in Deterministic Systems,
D. K. Campbell, J. D. Farmer, H. A. Rose,
Los Alamos Science 3, 66 (1982).

# Chapter 3

# People

## 3.1 Staff Members

— Eli Ben-Naim

— Gennady Berman

— Michael Chertkov

— Diego Dalvit

— Matthew Hastings

— Christopher Jarzynski

— Alan Lapedes

— Bradley Plohr

— Charles Reichhardt

— Harvey Rose

— David Sharp

— Zoltan Torkoczai

— Timothy Wallstrom

## 3.2 Postdocs

— Colm Connaughton

— Hasan Guclu

— Eduardo Lopez

— David Roberts

— Felipe Da Rosa

— Nandakishore Santhi

— Rolando Soma

— Razvan Teodorescu

## 3.3 Affiliates

— Shiyi Chen, John Hopkins University

— Boris Chernobrod, Los Alamos National Laboratory

— Gary Doolen, Los Alamos National Laboratory

— James Glimm, State University of New York, Stony Brook

— Shuling Hou, Los Alamos National Laboratory

— Aleksandr Kogan, Los Alamos National Laboratory

— Pavel Lushnikov, University of New Mexico

— Ronnie Mainieri, Institute for Physical Sciences

— Edward MacKerrow, IAT-1, Los Alamos National Laboratory

— Peter Milonni, Los Alamos National Laboratory

— Mikhail Stepanov, University of Arizona

— Natalia Vladimirova, University of Chicago

## 3.4 Students

2006-2007

— Henny Admoni, New York University

— Jaime Anguita, University of Arizona

— Kelson Castain

— Robert Hayre, UC, Davis

— Clinton Irvin

— Terrence Jones

— Jin Sub Kim, Seoul National University

— Lukas Kroc, Cornell University

— Andras Libal, Notre Dame University

— Brady Lindberg, Air Force Academy

— Qiming Lu, RPI

— Cody Mack, Notre Dame University

— Niall Mangan, Clarkson University

— Terrence Merritt

— Steven Oliver

— Lauren O'Malley, RPI

— Luca Pezze, Trente, Italy

— Marko Rodriguez, UC Santa Cruz

— Daniel Summerhays

— Joshua Thorp

— Federico Vazquez, Boston University

— Marija Vucelja, Weizmann Institute of Science

— Murat Yuksel, RPI

— Mew Bing Wan, Washington University in St. Louis

## 3.5 Visitors

2006-2007

— Yuri Antipov, Lousiana State University

— Roman Barankov, University of Illinois at Urbana, Champaign

— Daniel ben-Avraham, Clarkson University

— Carl Bender, Washington University, St. Louis

— Paul Berman, University of Michigan

— Miles Blencowe, Dartmouth College

— Stephen Boettcher, Emory University

— Dirk Bouwmeester, University of California

— Sergey Bravyi, IBM Watson Research Center

— Ken Brown, Massachusetts Institute of Technology

— Carlton Caves, University of New Mexico

— Antonio Celani, University of Nice, France

— George Chapline, Lawrence Livermore National Laboratory

— Vladimir Chernyak, Wayne State University

— Maria Chiofalo, Scuola Normale Superiore

— Andrew Childs, California Institute of Technology

— Oleksandr Chumak, National Academy of Sciences, Ukraine

— Aaron Clauset, University of New Mexico and Santa Fe Institute

— Herman Clercx, Eindhoven

— Ana Maria Contreras Reyes, Oxford University, England

— Scott Crane, US Naval Observatory

— Ricardo Decca, Indiana University - Purdue

— Francesco DeMartini, Universita ”La Sapienza”, Italy

— Luming Duan, University of Michigan

— Konstantin Efetov, University of Ruhr-Bochum, Germany

— S. Espa, Roma, Italy

— Greg Eyink, John Hopkins University

— Gregory Falkovich, Weizmann Institute of Science, Israel

— Rosario Fazio, International School for Advanced Studies, Italy

— Joshua Feinberg, Technion, Israel

— Alexander Fetter, Stanford University

— George Willard Ford, University of Michigan

— Steven Girvin, Yale University

— Vyacheslav Gorshkov, National Academy of Sciences Ukraine

— Robert Griffiths, Carnegie-Mellon University

— Thomas Halford, University of Southern California

— David Hall, Amherst College

— John Harnad, University of Montreal, Canada

— James Hartle, University of California

— Shlomo Havlin, Bar-Ilan University, Israel

— Kevin Henderson, University of Texas at Austin

— E. Hinds, Imperial College London

— Randy Hulet, Rice University

— Francesco Intravaia, Postdam University

— Philippe Jacquod, University of Arizona

— Daniel James, University of Toronto

— Hugh Jones, Imperial College London, England

— Byungnam Kahng, Seoul National University, Korea

— Mark Keller, National Institute of Standards and Technology/Boulder

— Igor Kolokolov, L.D. Landau Institute for Theoretical Physics, Russia

— Alexander O. Korotkevich, L.D. Landau Institute for Theoretical Physics, Russia

— Paul Krapivsky, Boston University

— Alex Kuzmich, Georgia Institute of Technology

— Paul Kwiat, University of Illinois at Urbana-Champaign

— Steve Lamoreaux, Yale University

— Chris Langer, National Institute of Standards and Technology

— Daniel Lathrop, University of Maryland

— Vladimir Lebedev, L.D. Landau Institute for Theoretical Physics, Russia

— Seung-Yeop Lee, University of Chicago

— Matt Leifer, Perimeter Institute

— Benjamin Lev, JILA

— Seth Lloyd, MIT

— Cyril Measson, Ecole Polytechnique Federale de Lausanne, Switzerland

— Marco Merkli, Memorial University of Newfoundland

— Alan Middleton, University of Syracuse

— Michael Moore, Ohio University

— Sergei Nechaev, LPTMS, Orsay, France

— Paulo Maia Neto, Universidade Federal de Rio de Janiero

— Sean Nolan, Washington DC

— Carlo Ottaviani, University of Barcelona

— John Oxford, Queen Mary College, England

— Luca Pezze, Univerista Degli Studi di Trento, Italy

— Evgeny Podivilov, Russian Academy of Sciences

— David Poulin, California Institute of Technology

— Nikolay Prokofiev, University of Massachusetts

— Mark Raizen, University of Texas at Austin

— Alexander Ramm, Kansas State University

— Michael Revzen, Technion- Isreal Institute of Technology

— Changehyun Ryu, National Institute of Standards and Technology

— Krzysztof Sacha, Jagellonian University, Poland

— Nandakishore Santhi, University of California, San Diego

— Peter Schwindt, National Institute of Standards and Technology

— Signe Seidlin, University of Southern California

— Michel Shats, Australian National University, Australia

— David Sherrington, Oxford University, England

— Gora Shlepnikov, Orsay, France

— Alexander Shnirman, University of Karlsruhe

— C. Simien, Rice University

— Felipe Siquiera, Rio de Janeiro University, Brazil

— Zuzanna Siwy, University of California, Irvine

— Pasquale Sodano, Universita di Perugia, Italy

— Salvatore Spagnolo, University of Palermo, Italy

— Dan Stamper-Kurn, University of California

— Jennifer Strabley, National Institute of Standards and Technology

— Fabricio Toscano, Centro Brasileiro de Pesquisas Fisicas, Brazil

— Joseph Traub, Columbia University

— Donald Turcotte, University of California, Davis

— Konstantin Turitsyn, L.D. Landau Institute for Theoretical Physics, Russia

— Alexander Vardy, University of California San Diego

— Lorenza Viola, Dartmouth College

— Natalia Vladimirova, University of Chicago

— Pascal Vontobel, HP-Labs, Palo Alto

— Vladan Vuletic, Massachusetts Institute of Technology

— Thad Walker, University of Wisconsin at Madison

— Paul Wiegmann, University of Chicago

— Liano Wu, University of Toronto

— Jon Yard, California Institute of Technology

— Peter Young, University of California, Santa Cruz

— Nan Yu, Jet Propulsion Laboratory

— Oleg Zaboronski, Warwick University, England

— Annette Zippelius, Goettingen University, Germany

— Michael Zwolak, California Institute of Technology

# Chapter 4

# Curriculum Vitae

## 4.1 Eli Ben-Naim

**Research Areas:**

— Statistical Physics

— Nonlinear Dynamics

— Random Processes

**Research Interests:**

— Granular Matter

— Nonequilibrium Dynamics

— Complex Networks

— Transport Processes

— Mathematical Biology

**Education:**

— B.S., Physics and Mathematics, Hebrew University, Jerusalem, Israel, 1990.

— Ph.D., Physics, Boston University, 1994

**Employment history:**

— Postdoctoral Fellow, University of Chicago, 1994-1996

— Postdoctoral Fellow, Los Alamos National Laboratory, 1996-1998

— Staff Member, Complex Systems Group, 1998-2006

— Group Leader, Complex Systems Group, 2006-present

**Selected Publications:**

— Stationary States and Energy Cascades in Inelastic Gases, E. Ben-Naim and J. Machta Phys. Rev. Lett. 94, 138001 (2005)

— Bifurcations and Patterns in Compromise Processes, E. Ben-Naim, P.L. Krapivsky, and S. Redner Physica D 183, 190 (2003)

— The Inelastic Maxwell Model, E. Ben-Naim and P.L. Krapivsky, Lecture Notes in Physics 624, 65 (2003)

— Knots and Random Walks in Vibrated Granular Chains, E. Ben-Naim, Z.A. Daya, P. Vorobieff, and R.E. Ecke Phys. Rev. Lett. 86, 1414 (2001).

— Shock Like Dynamics of Inelastic Gases, E. Ben-Naim, S.Y. Chen, G. D. Doolen, and S. Redner Phys. Rev. Lett. 83, 4069 (1999).

## 4.2 Gennady Berman

**Research Areas:**

— Nonlinear Dynamics

— Quantum Optics

— Probability Theory, Data Mining, Knowledge Discovery

**Research Interests:**

— Quantum Computation, Quantum Measurement

— Nano-devices

— Optical Communication

— Pattern Detection in Databases

**Education:**

— BS in Physics, Novosibirsk State University (NSU), Siberian Academgorodok, 1970.

— PhD in Physics (first), Kirensky Institute of Physics, Krasnoyarsk, Academgorodok, Russia, 1974.

— PhD (second), Institute of General Physics, Moscow, Russia, 1989.

**Employment history:**

— Junior Scientist, Kirensky Institute of Physics, Russia, 1974-1979.

— Senior Scientist, Kirensky Institute of Physics, Russia, 1979-1986.

— Department Head, Department of the Theory of Nonlinear Processes, Russia, 1986-1994.

— Technical Staff Member, Complex Systems Group, 1994-2002.

— Deputy Group Leader, Complex Systems Group, 2002-present.

**Selected Publications:**

— Crossover-time in quantum boson and spin systems, Lecture Notes in Physics, G.P. Berman, E.N. Bulgakov, D.D. Holm, Springer-Verlag, 1994.

— Introduction to quantum computers, G.P. Berman, G.D. Doolen, R. Mainieri, V.I. Tsifrinovich, World Scientific Publishing, 1998.

— Quantum chaos: A harmonic oscillator in a monochromatic wave, D.I. Kamenev, G.P. Berman, Rinton Press, 2001.

— Modern Physics and Technology for Undergraduates, L. Folan, V.I. Tsifrinovich, G.P. Berman, World Scientific Publishing, 2003.

## 4.3 Michael Chertkov

**Research Areas:**

— Statistical Physics

— Fluid Mechanics

— Information Theory

**Research Interests:**

— Statistical Hydrodynamics, Turbulence

— Information Theory

— Optical Communications

— Macromolecules

**Education:**

— M.Sc. in Physics, Novosibirsk State University, Russia, 1990

— Ph.D. in Physics, Weizmann Institute of Science, Israel, 1996

**Employment history:**

— Junior Researcher, Budker Institute, Novosibirsk, 1990-1992

— Dicke Postdoctoral Fellow, Department of Physics, Princeton University, 1996-1999

— J.R. Oppenheimer Postdoctoral Fellow, Los Alamos National Laboratory, 1999-2001

— Staff Member, Complex Systems group, Los Alamos National Laboratory, 2002-present

**Selected Publications:**

— Error correction on a tree: An instanton approach, M. Chertkov, V. Chernyak, M. Stepanov, B. Vasic, Phys. Rev. Lett. 93, 198702 (2004).

— Phenomenology of Rayleigh-Taylor Turbulence, M. Chertkov, Phys. Rev. Lett. 91, 115001 (2003).

— Probability of anomalously large Bit-Error-Rate in long haul optical transmission, M. Chertkov, V. Chernyak, I. Kolokolov, V. Lebedev Phys. Rev. E 68, 066619 (2003).

— Shedding and interaction of solitons in weakly disordered optical fibers, M. Chertkov, Y. Chung, A. Dyachenko, I. Gabitov, I. Kolokolov, V. Lebedev, Phys. Rev. E 67, 036615 (2003)

— Boundary effects on chaotic advection-diffusion chemical reactions, M. Chertkov, V. Lebedev, Phys. Rev. Lett. 90, 134501 (2003).

## 4.4 Diego Dalvit

**Research Areas:**

— Quantum Information

— Quantum Optics

— Nanoscience

**Research Interests:**

— Decoherence, Quantum-Classical Transition, Open Quantum Systems

— Physical Implementations of Quantum Information Processing

— Ion Traps, Casimir Forces, Cold Atomic Gases

— Physics of Quantum Simulations

— Dynamics and Control of Quantum Systems

— Quantum Vacuum Effects

**Education:**

— Licenciatura en Fisica, Buenos Aires University, Argentina, 1993.

— Ph.D., in Physics, Buenos Aires University, Argentina, 1998.

**Employment history:**

— Postdoctoral Fellow, Theoretical Division, Los Alamos National Laboratory, 1999-2001

— Technical Staff Member, Theoretical Division, Los Alamos National Laboratory, 2002-present

**Selected Publications:**

— Sub-Planck structures and Heisenberg-limited measurements, F. Toscano, D.A.R. Dalvit, L. Davidovich and W.H. Zurek, Phys. Rev. A 73, 023803 (2006)

— Decoherence and the Loschmidt Echo, F.M. Cucchietti, D.A.R. Dalvit, J.P. Paz and W.H. Zurek, Phys. Rev. Lett. 91, 210403 (2003)

— Decoherence in Bose- Einstein condensates: towards better and bigger Schroedinger cats, D.A.R. Dalvit, J. Dziarmaga and W.H. Zurek, Phys. Rev. A 62, 013607 (2000)

— Decoherence via the dynamical Casimir effect, D.A.R. Dalvit and P.A. Maia Neto, Phys. Rev. Lett. 84, 798 (2000)

— Problems on Statistical Mechanics, D.A.R. Dalvit, J. Frastai and I. Lawrie, Graduate Student Series in Physics, Institute of Physics Publishing (1999)

## 4.5 Matthew Hastings

**Research Areas:**

— Condensed Matter Physics

— Nonequilibrium Statistical Physics

— Soft Matter Physics

**Research Interests:**

— Correlated Electron Systems

— Topological Order

— Quantum Information

— Network Dynamics

— Fractal Growth

— Granular Matter

— Vortex Dynamics

**Education:**

— BS, in Mathematics and Physics, Yale University, 1994.

— PhD in Physics, Massachusetts Institute of Technology, 1997.

**Employment History:**

— R. H. Dicke Postdoctoral Fellow, Princeton University, 1997-2000

— Feynman postdoctoral Fellow, Los Alamos National Laboratory, 2000-2003.

— Technical Staff Member, Complex Systems Group, 2003-present

**Selected Publications:**

— Lieb-Schultz-Mattis in Higher Dimensions, Phys. Rev. B 69, 104431 (2004). M. B. Hastings,

— Do Vortices Entangle?, C. J. Olson Reichhardt and M. B. Hastings, Phys. Rev. Lett. 92, 157002 (2004).

— An epsilon-expansion for Small-World Networks, M. B. Hastings, Eur. Phys. Jour. B, 42, 297 (2004).

— Mean-Field and Anomalous Behavior on a Small-World Network, M. B. Hastings Phys. Rev. Lett., 91, 098701 (2003).

— Laplacian Growth as One-dimensional Turbulence, M. B. Hastings and L. S. Levitov, Physica D 116, 244 (1998).

## 4.6 Alan Lapedes

**Research Areas:**

— Computational Biology, Genomics

— Computational Physics

— Epidemiology

— Relativity

**Research Interests:**

— Influenza Modeling

— Protein Interactions

— Neural Networks

— Quantum Field Theory

**Education:**

— BA, in Physics, University of Virginia, 1973

— PhD, in Physics, Cambridge University, England, 1978

**Employment history:**

— Postdoctoral Fellow, Cambridge University, England, 1978

— Member, Institute for Advanced Studies, Princeton, 1979-1981

— Group Leader, Complex Systems Group, 1991-1994

— Technical Staff Member, Los Alamos National Laboratory, 1981-present

**Selected Publications:**

— Timing the ancestor of the HIV-1 pandemic strains, B. Korber, M. Muldoon, J. Theiler, F. Gao, R. Gupta, A. Lapedes, B.H. Hahn, S. Wolinsky, T. Bhattacharya, Science 288, 1789 (2000).

— Probabilistic code for DNA recognition by proteins of the EGR family, P.V. Benos, A.S. Lapedes, G.D. Stormo, J. Mol. Bio 323, 701 (2002).

— Predicting protein secondary structure using neural net and statistical methods, P. Stolorz, A. Lapedes, Y. Xia, J. Mol. Bio. 225, 363 (1992).

— A self-optimizing, nonsymmetrical neural net for content addressable memory and pattern-recognition, A. Lapedes, R. Farber, Physica D 22, 247 (1986).

## 4.7 Bradley Plohr

**Research Areas:**

— Fluid Mechanics

— Solid Mechanics

— Applied Mathematics

— Mathematical Physics

**Research Interests:**

— Shock waves & Nonlinear Waves

— Elasticity & Plasticity

— Fluid Instabilities, Multiphase Flows

**Education:**

— BS, in Physics and Mathematics, University of Dayton, 1975

— MA, in Physics, Princeton University, 1977

— PhD, in Physics, Princeton University, 1988

**Education:**

— Postdoctoral research associate, Rockefeller University, 1980-1982

— Associate research scientist, New York University, 1982-1984

— Professor, University of Wisconsin-Madison, 1984-1990

— Professor, State University of New York, Stony Brook, 1989-present

— Staff Member, Complex Systems Group, 2002-present

**Selected Publications:**

— Linearized analysis of Richtmyer-Meshkov flow for elastic materials, J.N. Plohr and B.J. Plohr, Jour. of Fluid. Mech. 537, 55 (2005)

— Organizing center for wave bifurcation in multiphase flow models, D. Marchesin, B.J. Plohr, D. Schecter, SIAM Jour. App. Math. 57, 1189 (1997)

— A Conservative Formulation for Plasticity, B.J. Plohr and D.H. Sharp, Adv. in App. Math. 13, 462 (1992)

— Dynamics of shear flow of a non-Newtonian fluid, D.S. Malkus, J.A. Nohel, B.J. Plohr, Jour. of Comp. Phys. 87, 464-87 (1990)

— The Riemann problem for fluid flow of real materials, R. Menikoff, and B.J. Plohr, Rev. of Mod. Phys. 61, 75 (1989)

## 4.8 Charles Reichhardt

**Research Areas:**

— Soft Matter Physics

— Condensed Matter Physics

— Material Science

**Research Interests:**

— Colloidal Matter, Granular Matter

— Glass Transition, Melting

— Dynamic Phase Transitions, Stochastic Transport

— Vortices in Superconductors, Quantum Dots

**Education:**

— B.S., Physics and Mathematics, University of California Irvine, 1993.

— Ph.D., Physics, 1998, University of Michigan, 1998

**Employment history:**

— Postdoctoral Associate, University of California Davis 1998-2000

— Feynman Postdoctoral Fellow, Center for Nonlinear Studies, Los Alamos National Laboratory , 2000-2003

— Technical Staff Member, Complex Systems Group, 2003-present

**Selected Publications:**

— Crossover from Intermittent to Continuum Dynamics for Locally Driven Colloids, C. Reichhardt and C.J. Olson Reichhardt, Phys. Rev. Lett 96, 028301 (2006).

— Multiscaling at Point J: Jamming is a Critical Phenomenon, J.A. Drocco, M.B. Hastings, C.J. Olson Reichhardt, and C. Reichhardt, Phys. Rev. Lett., 95, 088001 (2005).

— Noise at the Crossover from Wigner Liquid to Wigner Glass, C. Reichhardt and C.J. Olson Reichhardt, Phys. Rev. Lett 93, 176405 (2004).

— Charge Transport Transitions and Scaling in Disordered Arrays of Metallic Dots, C. Reichhardt and C.J. Olson Reichhardt, Phys. Rev. Lett., 90, 046802 (2003)

— Rectification and Phase Locking for Particles on Two Dimensional Periodic Substrates, C. Reichhardt, C.J. Olson, and M.B. Hastings, Phys. Rev. Lett., 89, 024101 (2002).

— Vortices Freeze like Window Glass" The Vortex Molasses Scenario, C. Reichhardt, A. van Otterlo, and G.T. Zimanyi, Phys. Rev. Let., 84, 1994 (2000).

## 4.9 Harvey Rose

**Research Areas:**

— Plasma Physics

— Laser Plasma Interactions

— Nonlinear Waves

— Fluid Dynamics

**Research Interests:**

— Inertial Confinement Fusion (ICF)

— Onset of stimulated Raman backscatter in a speckled laser beam

— Power limit on beam propagation due to self-focusing

**Education:**

— BS, City College of New York, 1968

— PhD, in Physics, Harvard University, 1975

**Employment:**

— Postdoctoral research associate, National Center for Atmospheric research, 1975-1976

— Postdoctoral research associate, Observatoire de Nice, Nice France, 1976-1977

— Postdoctoral Research Fellow, Theoretical Division, Los Alamos National Laboratory, 1977-1979

— Staff member, Theoretical Division, Los Alamos National Laboratory 1979-present

**Selected Publications:**

— Langmuir wave self-focusing versus decay instability, Harvey A. Rose, Phys. Plasmas 12, 012318 (2005).

— A self-consistent trapping model of driven electron plasma waves and limits on stimulated Raman scatter, Harvey A. Rose and David A. Russell, Phys. Plasmas 8, 4784 (2001).

— Laser beam deflection by flow and nonlinear self-focusing, H.A. Rose, Phys. Plasmas 3, 1709 (1996).

— Statistical Dynamics of Classical Systems, P.C. Martin, E.D. Siggia, and H.A. Rose, Phys. Rev. A 8 423-37 (1973).

## 4.10 Timothy Wallstrom

**Research Areas:**

— Statistics

— Probability Theory

— Mathematical Physics

— Applied Mathematics

**Research Interests:**

— Statistical Modeling, Inference

— Foundations of Statistics and Probability

— Statistical Learning

**Education:**

— AB, in history, Stanford University, 1979

— PhD, in physics, Princeton University, 1988

**Employment history:**

— Postdoctoral Research Fellow, Los Alamos National Laboratory, 1992-1995

— Staff Member, Geoanalysis Group, Los Alamos National Laboratory, 1995-1996

— Staff Member, Complex Systems Group, 1996-present

**Selected Publications:**

— The marginalization paradox does not imply inconsistency for improper priors, T.C. Wallstrom, math.ST/0310006.

— Effective flux boundary conditions for upscaling porous media equations, T.C. Wallstrom, M.A. Christie, L.J. Durlofsky, and D.H. Sharp, Transport in Porous Media 46, 139 (2002)

— A Stochastic Analysis of the Scale Up Problem for Flow in Porous Media, J. Glimm, D. H. Sharp, and H. Kim, and T. C. Wallstrom, Computational and Applied Mathematics, 17, 67 (1998).

— Stochastic Integrals: A Combinatorial Approach, G.C. Rota and T.C. Wallstrom, Annals of Probability, 25, 1257 (1997).

— On the inequivalence between the Schrodinger equation and the Madelung hydrodynamic equations, T.C. Wallstrom, Phys. Rev. A 49, 117 (1994).

# Chapter 5

# Activities

## 5.1 Conferences

Since 2006, the following conferences were organized by members of the Complex Systems Group.

— Algorithms, Inference & Statistical Physics,
May 1 - 4, 2007,
The Bishop's Lodge, Santa Fe, New Mexico

— Complexity of Biological and Soft Materials,
May 21-25, 2007,
Santa Fe, New Mexico

— Network science 2007,
May 21-25, 2007,
New York, New York

— Random Shapes,
April 16-20, 2007,
Institute for Pure and Applied Mathematics, University of California, Los Angeles

— Expanding Horizons: the Scientific Legacy of Brosl Hasslacher,
November 3-4, 2006,
Los Alamos National Laboratory, Los Alamos, New Mexico

— New Directions in Two-Dimensional Turbulence,
August 28 - September 1, 2006,
Los Alamos National Laboratory, Los Alamos, New Mexico

— Complex Networks Capability Workshop,
Tuesday, August 22, 2006,
Los Alamos National Laboratory, Los Alamos, New Mexico

— Socio-Technical Systems: Bridging the Scales,
August 14-18, 2006,
Los Alamos National Laboratory, Los Alamos, New Mexico

— APS March meeting, Topical group on nonlinear and statistical physics,
March 5-9, 2007,
Denver, Colorado

— Optimization in Complex Networks,
June 19-22, 2006,
Los Alamos, New Mexico

— Quantum - Classical Transition and Quantum Information,
June 18 - 30, 2006,
Benasque Center for Science, Benasque, Spain

## 5.2 Workshops

— Quantum Engineering Capability Workshop,
September 27, 2006,
Los Alamos National Laboratory, Los Alamos, New Mexico

— Complex Networks Capability Workshop,
August 22, 2006,
Los Alamos National Laboratory, Los Alamos, New Mexico

— Grand Challenge Workshop,
November 1-2, 2006,
Los Alamos National Laboratory, Los Alamos, New Mexico

## 5.3 Seminars

Since April 2006. These seminars were hosted or delivered by members of the complex systems group

— Singularities in Hele-Shaw flow,
Seung-Yeop Lee, University of Chicago

— Equivalent Hermitian Hamiltonians,
Hugh Jones, Imperial College London, England

— Earthquakes, Landslides, Wildfires, and Floods - What do they have in common?
Donald Turcotte, University of California, Davis

— Shear Suppression of Turbulence and Structural Changes in Plasma and 2D Fluids,
Michel Shats, Australian National University, Australia

— Quantum Computation, Entanglement, and Metrology,
Rolando Somma, P-21/T-13

— Spin Glasses,
Peter Young, University of California, Santa Cruz

— Large-Scale Simulations of Ising Spin Glasses on bond-diluted Lattices,
Stephen Boettcher, Emory University

— Should Physicists in Finite Dimensions Care about Computer Science?
Alan Middleton, University of Syracuse

— Numeric Verification of the Kinetic Equation in Weak Turbulence Theory,
Alexander Korotkevich, University of Arizona

— The Steady Fluctuation Relation for Lagrangian Power Fluctuations in Two Dimensional Turbulence,
Mahesh Bandi, MPA-10

— Some Recent Developments in the Theory of Open Quantum Systems,
Marco Merkli, Memorial University of Newfoundland, Canada

— Tau Functions, Matrix Integrals and Random Processes,
John Harnad, University of Montreal, Canada

— Effects of Diffusion on Large Scales in Passive Advection,
Igor Kolokolov, Landau Institute, Moscow

— Old Problems and New Results in Coding Theory,
Alexander Vardy, University of California, San Diego

— Algebraic List Decoding of q-ary Reed-Muller and Product Reed Solomon Codes,
Nandakishore Santhi, University of California, San Diego

— Reducing the Complexity of Graphical Models via Cycles,
Thomas Halford, University of Southern California, San Diego

— Casimir Effect for Arbitrary Materials,
Ana Maria Contreras Reyes, Oxford University, England

— How To Sum A Series, Part 2: How To Sum A Series When In Diverges,
Carl Bender, Washington University, St. Luis

— How to Sum a Series, Part 1: How To Sum A Series When In Converges,
Carl Bender, Washington University, St. Luis

— Randomness in Competitions,
Eli Ben-Naim, T-13

— Shock Waves and Solitons in Calogero Model: Emergence of Hydrodynamics in Many Body Theory,
Paul Wiegmann, University of Chicago

— New Elements for Modern Coding Theory: Van der Waals Curve and Maxwell Construction,
Cyril Measson, EPFL, Lausanne, Switzerland

— Graph-Cover Decoding: Connecting Iterative Decoding and Linear Programming Decoding,
Pascal Vontobel, HP-Labs, Palo Alto

— Viscoelasticity of Gels,
Annette Zippelius, Goettingen University, Germany

— When Superfluids are a Drag,
David Roberts, T-13

— Nonlinear Integral-Equation Formulation of Orthogonal Polynomials,
Eli Ben-Naim, T-13

— Synchronization and Extreme Fluctuations in Noisy Task-Completion Networks,
Hasan Guclu, T-13

— Statistical Physics of Infrastructure Networks,
Matthew Hastings, T-13

— Scalable and Reliable Senor Network Routing: Performance Study from Field Deployment,
Matthew Nassr, CCS-5

— Cold Atom Physics,
Bogdan Damski, T-DO

— Quantum Imaging,
Peter Milonni, T-DO

— Distribution of Particles Creating Wave-Focusing Materials,
Alexander Ramm, Kansas State University

— Structural Inference of Hierarchies in Networks,
Aaron Clauset, University of New Mexico and Santa Fe Institute

— Collective Excitations and Spin Squeezing in Simple Quantum Systems,
Paul Berman, University of Michigan

— Belief Propagation for Graph Bisection,
Allon Percus, CCS-3

— The Multicriterion Shortest Path Problem,
David Izraelevitz, D-6

— Stable Fermion Bag Solitons in the Massive Gross-Neveu Model: Inverse Scattering Analysis,
Joshua Feinberg, Technion, Israel

— Non-Hermitian Random Matrix Theory: Summation of Planar Diagrams, the single-ring Theorem and the Disk-Annulus Phase Transition,
Joshua Feinberg, Technion, Israel

— Loop Calculus in Statistical Physics and Information Theory,
Misha Chertkov, T-13

— Complexity in a Petri Dish,
Mahesh Bandi, T-CNLS

— The SK Spin Glass Revisted: New Novel Features and Issue/Questions for Complexity Physics, Optimization and non-linear Science,
David Sherrington, Oxford University, England

— The Many Names and Uses of Stochastic Loewner Evolution, SLE,
Razvan Teodorescu, T-13

— Experimental Study of direct and Inverse Cascade in Eletromagnetically Driven 2D Flows,
S. Espa, Universit'a a "La Sapienza", Italy

— Vorticity Production at No-slip Boundaries in 2D Confined Turbulence,
Herman Clercx, Eindhoven

— New Elements for Modern Coding Theory: Van der Waals Curve and Maxwell Construction,
Cyril Measson

— Diffusion-Limited One-Species Reactions in the Bethe Lattice,
Daniel ben-Avraham, Clarkson University

— Long Term Memory and Clustering in Climate and Seismic Activity,
Shlomo Havlin, Bar-Ilan University, Israel

— Scaling in Tournaments,
Federico Vazquez, Boston University

— Two-Dimensional Tubulent Cascades of Enstrophy, Energy and Circulation,
Greg Eyink, John Hopkins University

— Thermal Convection in Strongly Strafified Two-dimensional-like Fluid,
X. Wu, University of Pittsburgh

— Lagrangian Measurements and Coherent Structures in Driven Two-dimensional Turbulence,
Mike Rivera, MPA-10

— Late-Time Attractors for Patterns of Vortices and Jet Streams in A Rotating, Stratified Shear Flow, such as Jupiter's Atmosphere,
Philip S. Marcus, University of California, Berkeley

— Some Aspects of Geostrophic Turbulence,
Balu Nadiga, CCS-2

– The Spectra and Vortices of Two-dimensional Turbulence,
Colm Connaughton, T-13

— Potential Enstrophy Cascades in Rotating and Stratified Flows,
Susan Kurein, LANL, T-7

— Inverse Cascades and Conformally Invariant Curves,
Antonio Celani, Nice, France

— Experimental Studies of Mixing in Nonperiodic Flow,
Mike Twardos, MPA-10

— Origin, Spread, Virulence and Genetics of the 1889 and 1918 Pandemics: Relevance to the Avian Influenza H5N1 Threat,
John Oxford, Queen Mary College, England

— Geostrophic Turbulence - Energy and Enstrophy Cascades in the Atmosphere,
Michael Clark, University College, Dublin

— The Structure of Competitive Societies,
Federico Vazquez, Boston University

— From Optimal State Estimation to Efficient Quantum Algorithms,
Andrew Childs

— From an Ox Cart to a Covered Wagon: Efforts Toward Controlling More Trapped-ion Quantum Bits,
Signe Seidelin

— Rising Flame Bubbles and Rayleigh-Taylor Unstable Flames in the Boussinesq Limit,
Natalia Vladimirova, University of Chicago

— Universal Behavior of Optimal Paths in Weighted Networks with General Disorder,
Eduardo Lopez, T-13

— Probabilistic Quantum Computation and Quantum Simulation of Many-Body Physics with Ultracold Atoms,
Luming Duan

— The Scholarly Network and the Scholarly Communication Process,
Marko Rodriguez, T-13

— Random Networks: From Sparse to Dense,
Paul Krapivsky, Boston University

— Quantum Image Compression,
George Chapline, Lawrence Livermore National Laboratory

— Computational Complexity of Spin Hamiltonian Problems,
Sergey Bravyi, IBM Watson Research Center

— Optimizing a Randic Index for Graphs with Fixed Degree Sequence,
Zoltan Toroczkai, T-13

— Condensed Matter Physics Models for Molecular and Nuclear Physics,
Charles Rechhardt, T-13

— Exploring the Metabolic Network for Improved Functionality,
Natali Gulbahce, T-7

— Routing and Communication Building Blocks for Multi-hop,
Murat Yuksel, RPI

— Chip-Scale Automic Magnetometers,
Peter Schwindt, National Institute of Standards and Technology

— New Viewpoint On Ballistic Deposition: Statistics of Random Heaps,
Sergei Nechaev, LPTMS, Orsay

— Optimizing a Randic Index for Graphs with Fixed Degree Sequence,
Zoltan Toroczkai, T-CNLS

— Spintronics - A Retrospective and Perspective,
Stuart Wolf, University of Virginia

— Optimizing A Randic Index For Graphs With Fixed Degree Sequence,
Peter Erdos, Renyi Institute, Hungary

— Optimal fluctuation method for error correction,
Misha Stepanov, T-13

— Experiments with a "Particle in a Box": Bose-Einstein Condensates and Maxwell's Demon,
Mark Raizen, The University of Texas at Austin

— Thermodynamics at the Microscale,
Christopher Jarzynski, T-13

— Synthetic Analogues of Biological Voltage-Gated Channels. Fabrication of Ion-Current Rectifiers and Protein Sensors,
Zuzanna Siwy, University of California, Irvine

— Advanced Signal Detection For Magnetic Read Channel,
Oleg Zaboronski, Warwick, England

## 5.4 Quantum Lunch

Since January 2006. Diego Dalvit of the Complex Systems Group organizes the Quantum Lunch seminar series.

— Breakdown of the Adiabatic Limit in Low Dimensional Gapless Systems,
Anatoli Sergeevich Polkovnikov Boston University

— Cold Atoms on Atom Chips,
E. A. Hinds, Imperial College, London

— Quantum Phase Gate Operation Based on Nonlinear Optics: Semiclassical and Quantum Analysis,
Carlo Ottaviani, University of Barcelona, Spain

— Locality, Correlations, and Entanglement in Quantum Ground States,
Matthew B. Hastings, T-13

— Decoherence and Entanglement in Interacting Spin Baths,
Rosario Fazio, International School for Advanced Studies, Italy

— Visualizing the Formation and Dynamics of Quantum Defects in 4He Using Hydrogen Ice,
Daniel Lathrop, University of Maryland

— Spinor Bose-Einstein Condensates: A Dipolar Magnetic Superfluid,
Dan M. Stamper-Kurn, University of California

— Quantum Distribution Functions,
George Ford, University of Michigan

— Some Principles and Applications of Quantum Information Control: Toward a Subsystem-Theoretic Approach,
Lorenza Viola, Dartmouth College

— Resonance Theory of Decoherence and Thermalization,
Marco Merkli, Memorial University of Newfoundland

— Observation of Persistent Flow of a Bose-Einstein Condensate in a Toroidal Trap,
Changehyun Ryu, NIST

— Synchronization Versus Dephasing in the Pairing Dynamics of Cold Fermions,
Roman Barankov, University of Illinois at Urbana - Champaign

— Quantum Analysis of a DC SQUID Mechanical Displacement Detector,
Miles P. Blencowe, Dartmouth College

— Turning Back Time in an Optical Lattice,
Fernando Cucchietti, T-4

— Advanced Quantum Communication Protocols,
Paul G. Kwiat, University of Illinois at Urbana-Champaign

— Early Dynamics of an Ultrasound Neutral Plasma,
C.E. Simien, Rice University

— Molecular Regimes in Ultracold Fermi Gases,
Robert Griffiths, Carnegie-Mellon University

— Redistributing Quantum States,
Jon Yard, California Institute of Technology

— Quantum Metrology: Optimal Quantum Measurements,
Rolando Somma, P-21

— Dissipative Dynamics of Strongly Correlated Quantum Systems,
Michael Philip Zwolak, California Institute of Technology

— Geometrical Spin Dephasing in Quantum Dots,
Alexander Shnirman, University of Karlsruhe, Germany

— Quantum Phase Transitions, Entanglment and Density Functional Theory,
Liano Wu, University of Toronto, Canada

— A Semiclassical Theory of Decoherence,
Philippe Jacquod, University of Arizona

— Negative Probabilities in Quantum Mechanics,
James Hartle, University of California

— Quantum Imaging,
Peter W. Milonni, T-13

— Collective Excitations and Spin Squeezing in Simple Quantum Systems
Paul Berman, University of Michigan

— Atom Interferometry in Space for Fundamental Science and Practical Applications,
Nan Yu, Jet Propulsion Laboratory, California Institute of Technology

— Single and Twin Photons from Many Entangled Atoms,
Vladan Vuletic, Massachusetts Institute of Technology

— Examination of the Charge Quantum in a Single-Electron Pump,
Mark W. Keller, NIST/Boulder

— Iterative Decoding of Quantum Error Correcting Codes,
David Poulin, California Institute of Technology

— Towards a Continuously Operating Atomic Fountain Clock,
Scott Crane, US Naval Observatory

— Quantum Key Distribution with Decoy Levels,
Danna Rosenberg, P-21

— Binary Bose-Einstein Condensates,
David Hall, Amherst College

— A Double Well Optical Lattice for Dynamically Manipulating Pairs of Cold Atoms,
Jennifer Strabley, NIST

— A Mini-Course on the Aharonov-Jones-Landau Algorithm for Approximating the Jones Polynomial,
Howard Barnum, CCS-3

— Factorization and Physical Representations,
Michael Revzen, Technion, Israel

— Quantum Annealing for optimization problems on random graphs,
Vadium Smelyanskiy, NASA Ames Research Center

— Adiabaticity in open quantum systems: theory and applications to adiabatic quantum computation and geometric phases,
Daniel Lidar, University of Southern California

— Quantum Gravity from Quantum Computation: Applications,
Seth Lloyd, Massachusetts Institute of Technology

— Whither Quantum Computing,
Daniel James, University of Toronto

— From Optimal State Estimation to Efficient Quantum Algorithms,
Andrew Childs, California Institute of Technology

— Quantum Networking with Atoms and Photons,
Alex Kuzmich, Georgia Institute of Technology

— From an Ox Cart to a Covered Wagon: Efforts Toward Controlling More Trapped-ion Quantum Bits,
Signe Seidelin, University of Southern California

— Experiments with a Bose-Einstein Condensate in a Quasi-1D Waveguide,
Kevin Henderson, University of Texas at Austin

— Probabilistic Quantum Computation and Quantum Simulation of Many-Body Physics with Ultracold Atoms,
Luming Duan, University of Michigan

— Strong Coupling Cavty QED and Sperconducting Qubits,
Steven Girvin, Yale University

— Computational Complexity of Spin Hamiltonian Problems,
Sergey Bravyi, IBM Watson Research Center

— Berry Phase Oscillations of the Kondo Effect in Single-molecule Magnets,
Eduardo Mucciolo, University of Central Florida

— Lieb-Schultz-Mattis in Higher Dimensions,
Matthew Hastings, T-13

— A Causal Network Formalism for Quantum Information,
Matt Leifer, Perimeter Institute, Waterloo, Canada

— Cavity QED with Atom Chips and Micro-Resonators,
Benjamin Lev, JILA

— Qubit Complexity of Continuous Problems Joseph M. Traub, Columbia University

— Chip-Scale Automic Magnetometers,
Peter Schwindt, National Institute of Standards and Technology

— Experiments with a "Particle in a Box": Bose Einstein Condensates and Maxwell's Demon,
Mark Raizen, University of Texas at Austin

— GHZ Correlations are Just a Bit Nonlocal,
Carlton Caves, University of New Mexico

— High Fidelity Quantum Information Processing with Ions,
Chris Langer, National Institute of Standards and Technology

— Casimir Effect And Interaction Between Surface Plasmons,
Francesco Intravaia, Postdam University

— A Causal Network Formalism for Quantum Information,
Matt Leifer, Perimeter Institute, Waterloo, Canada

— Quantum Information A Promise for Revolution In Information Processing,
Raymond Laflamme, University of Waterloo, Canada

— Paring and Phase Separation in a Polarized Fermi Gas,
Randy Hulet, Rice University

— Quantum Manipulations Using Rydberg Atoms,
Thad Walker, University of Wisconsin at Madison

— How can superfluidity occur in a crystalline solid: He-4 superglass,
Nikolay Prokofiev, University of Massachusetts

— Quantum Simulations of Physical Systems,
Ken R. Brown, Massachusetts Institute of Technology

— Entangled photons, solid-state cavity QED, and the quest for macroscopic quantum superpositions,
Dirk Bouwmeester, University of California

— Quantum Macroscopic Coherence and/or Topological Order in Josephson Junction Networks,
Pasquale Sodano, Universita di Perugia, Italy

— Deterministic, Long-Distance Teleportation of Atomic Qubits Via Optical Interferometry,
Michael G. Moore, Ohio University

— N-particle Bogoliubov vacuum state,
Krzysztof Sacha, Jagellonian University, Poland

— Realization of a Decoherence-free Mesoscopic Quantum Superposition,
Francesco DeMartini, Universita "La Sapienza", Italy

— Equilibrium and nonequilibrium phenomena in the BCS-BEC crossover of atomic Fermi gases,
Maria Luisa Chiofalo, Scuola Normale Superiore

## 5.5 Whiteboard Seminars

A seminar series organized by Misha Chertkov and Eli Ben-Naim of the complex systems group

— Doi-Peliti Methods for Non-Commuting Observables,
Eric Smith, Santa Fe Institute

— Optimal Fluctuation Approach to a Directed Polymer in a Random Medium,
Igor Kolokolov, Landau Institute, Russia

— Effects of Diffusion on Large Scales in Passive Advection,
I. Kolokolov, Landau Institute, Russia

— Stable Fermion Bag Solitons in the Massive Gross-Neveu Model: Inverse Scattering Analysis,
Joshua Feinberg, Technion, Israel

— The Motion of Molecular "Spiders",
Paul Krapivsky, Boston University

— Passive scalar statistics in peripheral regions,
Vladimir Lebedev, Landau Institute, Russia

— Scaling relations following from conservation of flux for driven dissipative systems,
Oleg Zaboronsky, Warwick University, England

— Droplets in a Turbulent Air Flow,
Misha Stepanov, T-13

— Phase Transitions and Integer Partitions,
Eli Ben-Naim, T-13

— Statistical physics of the Burgers Equation with Stochastic Pumping,
Igor Kolokolov, Landau Institute, Russia

— Loop Calculus in Statistical Physics and Information Science,
Misha Chertkov, T-13

# Chapter 6

# Publications

## 6.1 2006

1. Stickiness in Hamiltonian systems: From sharply divided to hierarchical phase space,
   E.G. Altmann, A.E. Motter, H. Kantz,
   Phys. Rev. E 73, 026207 (2006)

2. Conformal Invariance and Stochastic Loewner Evolution Processes in Two-Dimensional Ising Spin Glasses
   C. Amoruso, A.K. Hartmann, M.B. Hastings, M.A. Moore,
   Phys. Rev. lett. 97, 267202 (2006).

3. Dynamics of Multi-Player Games
   E. Ben-Naim, B. Kahng, J.S. Kim,
   J. Stat. Mech. P07001 (2006).

4. Weak disorder in Fibonacci sequences
   E. Ben-Naim, P.L. Krapivsky,
   J. Phys. A 39, L301 (2006).

5. Alignment of Rods and Partition of Integers
   E. Ben-Naim, P.L. Krapivsky,
   Phys. Rev. E 73, 031109 (2006).

6. On the structure of competitive societies,
   E. Ben-Naim, F. Vazquez, S. Redner,
   Eur. Phys. Jour. B 49, 531 (2006).

7. Parity and Predictability of Competitions,
   E. Ben-Naim, F. Vazquez, S. Redner,
   J. Quant. Anal. in Sports Vol 2: No. 4, Article 1 (2006).

8. Implementation of quantum logic operations and creation of entanglement between two nuclear spin qubits with constant interaction,

G.P. Berman, G.W. Brown, M.E. Hawley, D.I. Kamenev, V.I. Tsifrinovich,
Int. Jour. Quant. Info. 4, 975 (2006).

9. Spin diffusion and relaxation in solid state spin quantum computer,
G.P. Berman, B.M. Chernobrod, V.N. Gorshkov, V.I. Tsifrinovich,
Phys. Lett. A 352, 107 (2006).

10. Photon distribution function for long-distance propagation of partially coherent beams through the turbulent atmosphere,
G.P. Berman, A.A, Chumak,
Phys. Rev. A 74, 013805 (2006).

11. Quantum dynamics in the Fermi-Pasta-Ulam problem,
Berman, GP; Tarkhanov, N,
Int. Jour. Theor. Phys. 45, 1865 (2006).

12. Lieb-robinson bounds and the generation of correlations and topological quantum order,
S. Bravyi, M.B. Hastings, F. Verstraete,
Phys. Rev. Lett. 97, 050401 (2006).

12. Thermal and dissipative effects in Casimir physics M. Brown-Hayes,
J.H. Brownell, D.A.R. Dalvit, W.J. Kim, A. Lambrecht, et al
J. Phys. A 39, 6195 (2006).

14. Bogoliubov-Cerenkov radiation in a Bose-Einstein condensate flowing against an obstacle,
I. Carusotto, S.X. Hu, L.A. Collins, A. Smerzi,
Phys. Rev. Lett. 97, 260403 (2006).

15. Universal behavior of optimal paths in weighted networks with general disorder,
Y.P. Chen, E. Lopez, S. Havlin, H.E. Stanley,
Phys. Rev. Lett. 96, 068702 (2006).

16. Path-integral analysis of fluctuation theorems for general Langevin processes,
V.Y. Chernyak, M. Chertkov, C. Jarzynski,
J. Stat. Mech. P08001 (2006).

17. Loop series for discrete statistical models on graphs,
M. Chertkov, V.Y. Chernyak,
J. Stat. Mech. P06009 (2006).

18. Loop calculus in statistical physics and information science,
M. Chertkov, V.Y. Chernyak,
Phys. Rev. E 73, 065102 (2006).

19. Cluster-cluster aggregation as an analogue of a turbulent cascade: Kolmogorov phenomenology,

scaling laws and the breakdown of self-similarity,
C. Connaughton, R. Rajesh, O. Zaboronski, Physica D 222, 97 (2006).

20. Dynamics of open bosonic quantum systems in coherent state representation,
D.A.R. Dalvit, G.P. Berman, M. Vishik,
Phys. Rev. A 73, 013803 (2006).

21. Quantum metrology at the Heisenberg limit with ion trap motional compass states,
D.A.R. Dalvit, R.L. De Matos, F. Toscano,
New Jour Phys 8, 276 (2006).

22. Exact Casimir interaction between eccentric cylinders,
D.A.R. Dalvit, F. Lombardo, F.D. Mazzitelli, R. Onofrio,
Phys. Rev. A 74, 020101 (2006).

23. The dynamical Casimir effect for different geometries,
D.A.R. Dalvit, F.D. Mazzitelli, X.O. Millan,
J. Phys. A 39, 6261 (2006).

24. Congestion-gradient driven transport on complex networks,
B. Danila, Y. Yu, S. Earl, J.A. Marsh, Z. Toroczkai, K.E. Bassler,
Phys. Rev. E 74, 046114 (2006).

25. Experimental characterization of vibrated granular rings,
Z.A. Daya, E. Ben-Naim, R.E. Ecke,
Eur. Phys. Jour. E 21, 1 (2006).

26. Synchronization landscapes in small-world-connected computer networks,
H. Guclu, G. Korniss, M.A. Novotny, Z. Toroczkai, Z. Racz,
Phys. Rev. E 73, 066115 (2006).

27. Community detection as an inference problem,
M.B. Hastings,
Phys. Rev. E 74, 035102 (2006).

28. Systematic series expansions for processes on networks,
M.B. Hastings,
Phys. Rev. Lett. 96, 148701 (2006).

29. Solving gapped hamiltonians locally,
M.B. Hastings,
Phys. Rev. b 73, 085115 (2006).

30. Spectral gap and exponential decay of correlations,
M.B. Hastings, T. Koma,
Comm. Math. Phys. 265, 781 (2006).

31. Universal scaling relations in strongly anisotropic materials,
M.B. Hastings, C. Mudry,
Phys. Rev. lett. 96, 027216 (2006).

32. Beyond the Landau criterion for superfluidity,
S. Ianeselli, C. Menotti, A. Smerzi,
A J. Phys. B 39, S135 (2006).

33. Rare events and the convergence of exponentially averaged work values,
C. Jarzynski,
Phys. Rev. E 73, 046105 (2006).

34. Work fluctuation theorems and single-molecule biophysics,
C. Jarzynski,
Prog. Theor. Phys. Sup 165, 1 (2006).

35. Entropy of averaging for compressible two-pressure two-phase flow models,
H. Jin, J. Glimm, D.H. Sharp,
Phys. Lett. A 360, 114 (2006).

36. Compressible two-pressure two-phase flow models,
H. Jin, J. Glimm, D.H. Sharp,
Phys. Lett. A, 353, 469 (2006).

37. Influence of qubit displacements on quantum logic operations in a silicon-based quantum computer with constant interaction,
D.I. Kamenev, G.P. Berman, V.I. Tsifrinovich,
Phys. Rev. A 74, 042337 (2006).

38. Creation of entanglement in a scalable spin quantum computer with long-range dipole-dipole interaction between qubits,
D.I. Kamenev, G.P. Berman, V.I. Tsifrinovich,
Phys. Rev. A 73, 062336 (2006).

39. Scaling in small-world resistor networks,
G. Korniss, M.B. Hastings, K.E. Bassler, M.J. Berryman, B. Kozma, D. Abbott,
Phys. Lett. A 350, 324 (2006).

40. Dynamics, rectification, and fractionation for colloids on flashing substrates,
A. Libal, C. Reichhardt, B. Janko, C.J.O. Reichhardt,
Phys. Rev. Lett. 96, 188301 (2006).

41. Realizing colloidal artificial ice on arrays of optical traps,
A. Libal, C. Reichhardt, C.J.O. Reichhardt,
Phys. Rev. Lett. 97, 228302 (2006).

42. Heterogeneities and topological defects in two-dimensional pinned liquids,
J.X. Lin, C. Reichhardt, Z. Nussinov, L.P. Pryadko, C.J.O. Reichhardt,
Phys. Rev. E 73, 061401 (2006).

43. Anomalous electrical and frictionless flow conductance in complex networks,
E. Lopez, S. Carmi, S. Havlin, S.V. Buldyrev, H.E. Stanley,
Physica D 224, 69 (2006).

44. Simplified shock conditions for large-strain thermo-visco-plasticity,
B.J. Plohr, J.N. Plohr,
AIP Conf. Proc. 845, 343 (2006). .

45. Exact zero-point interaction energy between cylinders,
F.D. Mazzitelli, D.A.R. Dalvit, F.C. Lombardo,
New Jour. Phys 8, 240 (2006).

46. Intermittent polaron dynamics: Born-Oppenheimer approximation out of equilibrium,
D. Mozyrsky, M.B. Hastings, I. Martin,
Phys. Rev. E 73, 035104 (2006).

47. Scale dependence of the coarse-grained velocity derivative tensor: Influence of large-scale shear on small-scale turbulence,
A. Naso, M. Chertkov, A. Pumir,
Jour Turbulence 7, 1 (2006).

48. Synchronization is optimal in nondiagonalizable networks,
T. Nishikawa, A.E. Motter,
Phys. Rev. E 73, 065106 (2006).

49. Nonlinear beam splitter in Bose-Einstein-condensate interferometers,
L. Pezze, A. Smerzi, G.P. Berman, A.R. Bishop, L.A. Collins,
Phys. Rev. A 74, 033610 (2006).

50. Phase sensitivity of a Mach-Zehnder interferometer,
L. Pezze, A. Smerzi,
Phys. Rev. A 73, 011801 (2006). .

51. Scaling relations in the quasi-two-dimensional Heisenberg antiferromagnet,
A. Praz, C. Mudry, M.B. Hastings,
Phys. Rev. B 74, 184407 (2006).

52. Lengthscales and cooperativity in DNA bubble formation,
Rapti, Z; Smerzi, A; Rasmussen, KO; Bishop, AR; Choi, CH; Usheva, A,
EuroPhys. Lett. 74, 540 (2006).

53. Statics and dynamics of two-dimensional vortex liquid crystals,
C. Reichhardt, C.J.O. Reichhardt,
Europhys. Lett. 75, 489 (2006).

54. Cooperative behavior and pattern formation in mixtures of driven and nondriven colloidal assemblies,
C. Reichhardt, C.J.O. Reichhardt,
Phys. Rev. E 74, 011403 (2006).

55. Coarsening of topological defects in oscillating systems with quenched disorder,
C. Reichhardt, C.J.O. Reichhardt,
Phys. Rev. E 73, 046122 (2006).

56. Crossover from intermittent to continuum dynamics for locally driven colloids,
C. Reichhardt, C.J.O. Reichhardt,
Phys. Rev. Lett. 96, 028301 (2006).

57. Ratchet effect and nonlinear transport for particles on random substrates with crossed ac drives,
C. Reichhardt, C.J.O. Reichhardt,
Phys. Rev. e 73, 011102 (2006).

58. Vortex configurations and dynamics in elliptical pinning sites for high matching fields,
C.J.O. Reichhardt, A. Libal, C. Reichhardt,
Phys. Rev. B 73, 184519 (2006).

59. Electrophoresis of DNA on a disordered two-dimensional substrate,
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